Environmental Dynamics and Resource Management in the U.S. National Parks

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Introduction

In 1916 the U.S. National Park Service was charged by the Congress with a dual management responsibility—to preserve some of the great natural areas in North America, and to provide for the enjoyment of the people who visit these areas. Some have described this duality as a dilemma with "Preservation" carved on one horn and "Use" on the other. However, Congress clearly did not see the management mandate as an either-or situation or as a case of preservation vs. use. Indeed, in the Organic Act of 1916—the Magna Carta of the U.S. National Park Service—Congress twice used the singular in referring to the fundamental purpose of the national parks, monuments, and reservations: "To conserve the scenery and the natural and historic objects and wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (National Park Service, 1970).

Over the intervening decades, this purpose has been restated by every Secretary of the Department of the Interior and Director of the National Park Service, by presidents and Congress, in speeches and statements and policy directives, in legislation and supporting documentation, in word and deed. The policy mandate has not been changed, but management practice has. Visitation management has become so much more sophisticated than resource management that resource use threatens to overwhelm resource preservation. The result is the same as if a policy decision had been made to give primary emphasis to visitation.

On May 13, 1918, Secretary of the Interior Franklin K. Lane, in a letter to Director of the National Park Service Stephen T. Mather, outlined the administrative policy of the National Park Service: "Every activity of the service is subordinate to the duties imposed upon it to faithfully preserve the parks for posterity in essentially their natural state" (National Park Service, 1970).

The solution is not to ignore the visitor or to deemphasize visitation management, but better to understand the nature and function of the resource and to improve resource management. This is not a management objective or policy goal; it is a duty mandated by the Congress and the people of the United States.

The Dynamics of Natural Systems

All natural systems are dynamic, some more obvious than others; change is nature's constant. Stability is both rare and short-lived in nature, particularly in the spectacular environments that comprise the National Park System. In these areas resource management must be more than well-intentioned; it must be well-grounded in the dynamics of natural systems and be designed to accommodate and respond to the challenges imposed by constant change (Fig. 1).

The primary characteristic of natural environments is the interaction of their most dynamic parts or elements through time. The first step in resource management is to understand the dynamics of natural systems and their interacting elements.

There are three distinct changes operating in natural systems, each producing its own dynamic state (Dolan and Hayden, 1974). These states pose different challenges to the resource manager and demand individual responses.

Steady state. Most resource managers recognize and understand the numerous characteristics of recurrent, steady changes that define the daily, seasonal, annual, or life cycles of organisms, environments, and natural systems. These changes tend to drive natural systems toward an equilibrium or "Steady State." If these cycles were the only changes in natural systems, resource management would not be a major issue within the National Park Service. But, most natural systems are much more dynamic and, unfortunately, many resource management programs are modeled on "Steady State" dynamics.

Eddy state. The apparently erratic changes associated with extreme natural events are both dramatic and at times disconcerting. They upset the best management plans, so that violent storms, earthquakes, landslides, vol-

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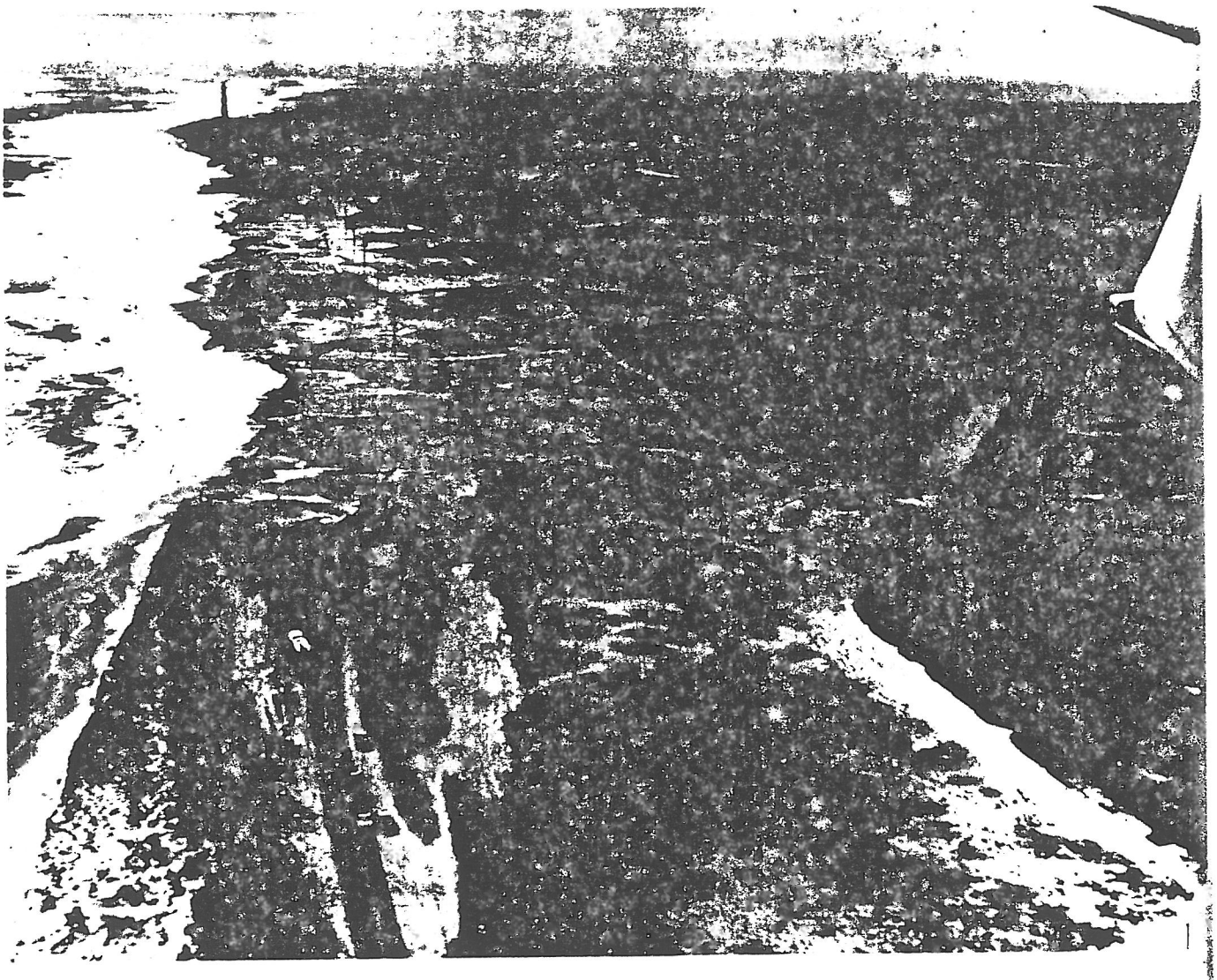

Fig. 1 Winter storms at Cape Hatteras frequently result in major changes in the landscape, regardless of plans and management goals. (NPS photo).

canic eruptions, fires, precipitous population declines, and other episodic events are described as catastrophic. But these changes are not catastrophic in nature—in fact, they are essential natural processes and if there is an environment in which Eddy States should be accepted with equanimity and interpreted as beneficial, that environment is the National Park System.

Trend state. The systematic changes that define the "Trend State" may or may not clearly produce defined events. They may be so gradual or occur over such a long time as to be virtually imperceptible. "Trend States" may be as obvious as vegetative succession or dune migration or as subtle as organic soil development or sea level rise. Sometimes the nature, direction, or magnitude of the "Trend States" may be a matter of scientific debate or controversy, in which cases all the resource manager can do is to monitor both the debate and the resource and make decisions that are not irreversible.

Man's influence. The principal agents of change in natural systems are geophysical and biological processes. Increasingly, though, resource managers have to cope with environmental changes caused by man. Man

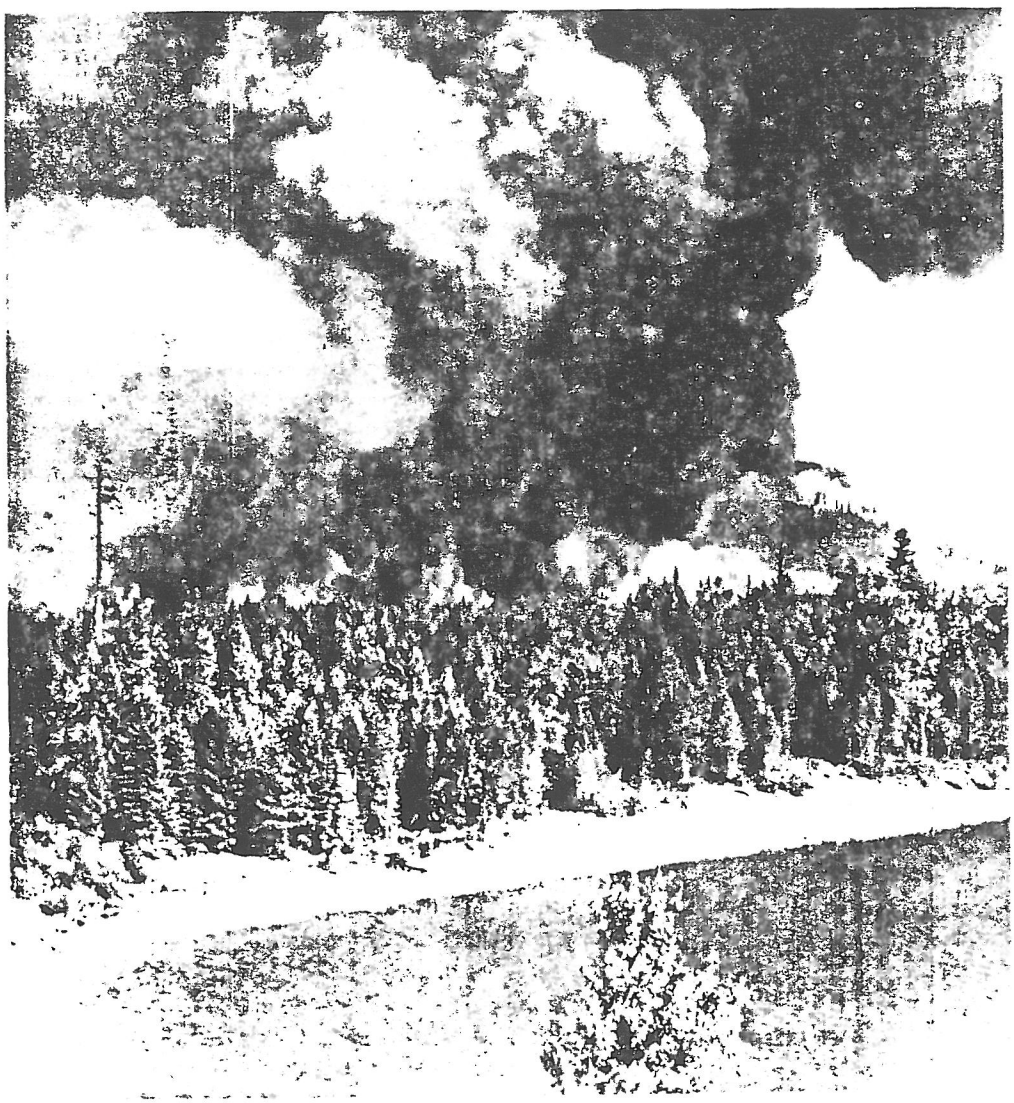

Fig. 2 Extensive forest fires are essential in some forest ecosystems and they may occur only following years of litter accumulation. (NPS photo).

induced changes may alter or even produce new "Steady," "Eddy," or "Trend States" in natural systems. These man-induced states may be the result of activities outside the national parks and beyond the control of the park resource manager. Others may be intended or inadvertent results of park management programs or policies.

Managing Change in Natural Systems

The management significance of these changes varies considerably. Within any given park or natural system several different "Steady," "Eddy," and "Trend States" will be in simultaneous operation, manifesting themselves in different ways. Geophysical processes fuel their own states of change, but they may also trigger biological responses, thereby setting in motion new sets and processes. "Eddy State" events may retard, reverse, or accelerate "Trend States," or force numerous changes in "Steady State" routines. No resource management plan that fails to take into account these dynamic processes of natural change can hope to succeed.

For each natural system or physical environment, there exists a number of critical processes that must be monitored, those processes whose measurements are the vital signs of the natural system.

In a forested park, the resource-manager is aware of

the hazard of fire, and will undoubtedly have a fire management plan. Fire is an "Eddy State," one of the few that are clearly recognized in park resource management plans (Kilgore, 1975). The natural process is not fire, but oxidation. In its "Steady State" it manifests itself in the chemical decomposition of leaf litter, dead trees, and other organic debris. The "Trend State" change will be an increase in the rate of oxidation with the accumulating depth of litter. All three states have management significance. In the "Steady State," until the oxidation process is under way, there exists a substantial fire hazard. In the "Trend State" the fire hazard increases with the accumulated depth of organic material (Fig. 2).

If a park contains one or more important ponds or lakes, the resource manager will be aware of the eutrophication process. In its "Steady State," that process will be measurable as an annual rate of detrital production and debris accumulation. The "Eddy State" will include the sudden inputs of nutrients and solid matter in storm runoff. The "Trend State" change is toward ultimate eutrophy and the filling in of the basin with accumulated debris and detrital material. The eutrophic process will trigger and be accompanied by a secondary process: vegetative change and plant succession. This is a fairly complicated process, but one that resource managers know and understand. The management significance includes appropriate responses to the changing nature of the pond's recreational and interpretive potentials , the acceleration of the process caused by fire within the watershed, and the impacts upon the process of any changes in water quality or watershed drainage caused by natural conditions or other park programs.

Because most of the elements of steady change are cyclical, the "Steady State" is by far the most predictable. "Steady State" change is fairly routine, and lends itself to a routine management response. Park resource managers respond adequately to the modest demands imposed by "Steady State" dynamics.

Least predictable of the dynamic states, the "Eddy State" is the one that causes serious management problems. The temptation is great to "curse the fates" for sending these extreme events. However, it is difficult to imagine Cape Hatteras without storms, Mt. Lassen without vulcanism, the Everglades without drought and fire, or Glacier Bay without ice surges. The "Eddy State" events are often responsible for the creation and development of the physical and biological elements and special character that make an area worthy of inclusion in the National Park System.

If "Trend States" were not so often poorly understood, they might be as predictable as "Steady States." But our information is short, so projection of trend curves of slowly changing processes involves risks. "Steady States" may account for the largest part of the resource management program and budget, and "Eddy States" may require, in some parks, massive emergency commitments of money and manpower. But "Trend States" may be the most important of all to the resource management plan (Fig. 3).

"Trend State" changes usually require a response at the most basic level of resource management planning. Failure to take into account such trends as sea level rise, fluvial erosion, and deposition, or climate change will doom any resource management plan to ultimate failure—the park will become increasingly difficult and costly to administer, and the plan's failure may result in permanent impairment or even destruction of the very resource it was intended to protect and maintain.

Management options. Within national parks accommodation of or adaptation to change is by far the easiest, least costly, most effective, and most appropriate response to natural change. Non-interference with natural processes is the surest course to follow in conserving scenic, wildlife, and other natural resources "unimpaired for the enjoyment of future generations" and "in essentially their natural state."

Too often, resource managers in the National Park Service and other land management agencies attempt to resist or to alter natural processes to solve problems. Usually such actions result in numerous secondary problems that can be extremely difficult and costly to mitigate. All three states of change can be altered—at least in theory. The "Steady State" is the easiest and least expensive to affect, but seldom is modification necessary to solve problems. In contrast, by modifying a primary process, the "Eddy State" impact can be checked or modified, but only with considerable difficulty, at great cost, and with a resultant intensification of secondary impacts of a "Trend State."

At Cape Hatteras National Seashore, for example, barrier dunes were built and stabilized to check the wave runup and overwash of great storms—"Eddy State" processes (Dolan, 1973). While the dunes did tend to hold back the storm waves for a while, they also prevented the cross-island transport of sediment, thus starving the soundside marshes of sediment, and exposing the barrier islands to erosion on both sides as the level of the sea continued to rise—the "Trend State." Millions of dollars were expended over two decades of increasingly frequent barrier dune maintenance and beach nourishment to

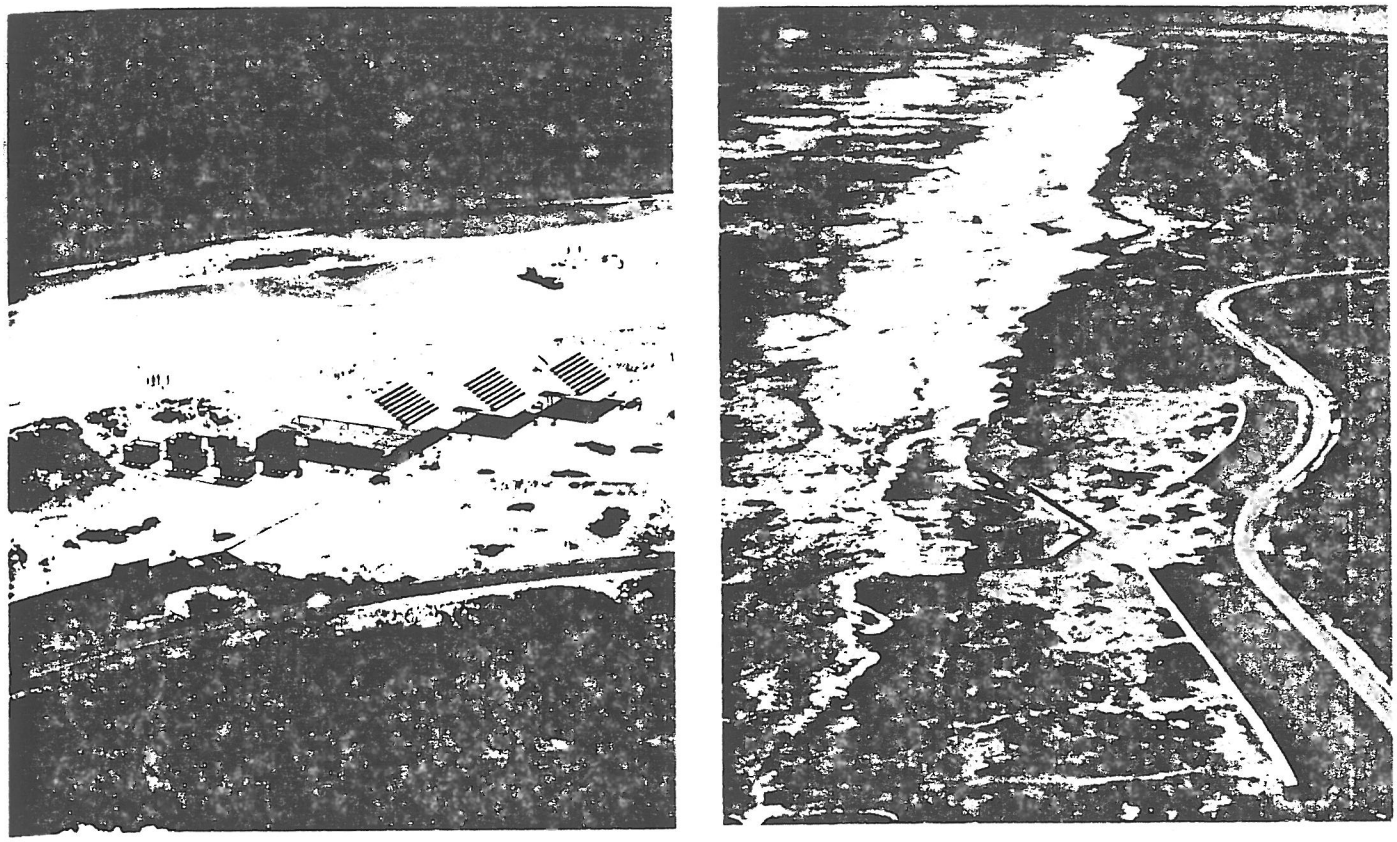

Fig. 3a & b With the current trend of a rising sea level, permanent developments may not be permanent. In this case the "Trend State" (sea level) resulted in rapid landscape change at Coquina Beach, North Carolina. (NPS photo).

replace eroded sediments (Fig. 4). As sea level continues to rise, the storm-wave height becomes greater relative to the stabilized "managed" island. Facing the ultimate failure of the system, the National Park Service decided not to continue maintaining the barrier dune system. Besides the loss of funds and management resources, the effort to control the "Eddy State" resulted in an extensive alteration of the barrier islands in violation of the Organic Act of 1916 as well as the specific mandate of the legislation establishing the seashore.

Some "Trend States" are amenable to alteration or resistance and some are not. But even those that are may require enormous resources and energy over an infinite span of time, and alterations of "Trend State" impacts may change the character and nature of an area or system completely.

It must be recognized that any management attempt to resist or alter any state of change or natural process is an extreme response to a problem, one that will virtually always result in violation of the fundamental mandate to conserve resources unimpaired and in a natural state. As such, these actions should not be taken lightly. They should be resorted to only in emergencies, such as in the case of threats to the lives or safety of visitors, or after careful policy deliberations, i.e., when the threat is to historic structures or other elements within the administrative purview of the National Park Service. Any such decision must take into account the inevitable appearance of secondary problems which may not be mitigated without further damage to the resource.

At Sequoia-Kings Canyon, Yosemite, Everglades, and several other parks, it was decided to alter a "Trend State" (plant succession) that had been created by earlier management programs which interfered with an "Eddy State" (fire) (Kilgore, 1976). In these cases the later alterations seem justified from a policy point of view, but major

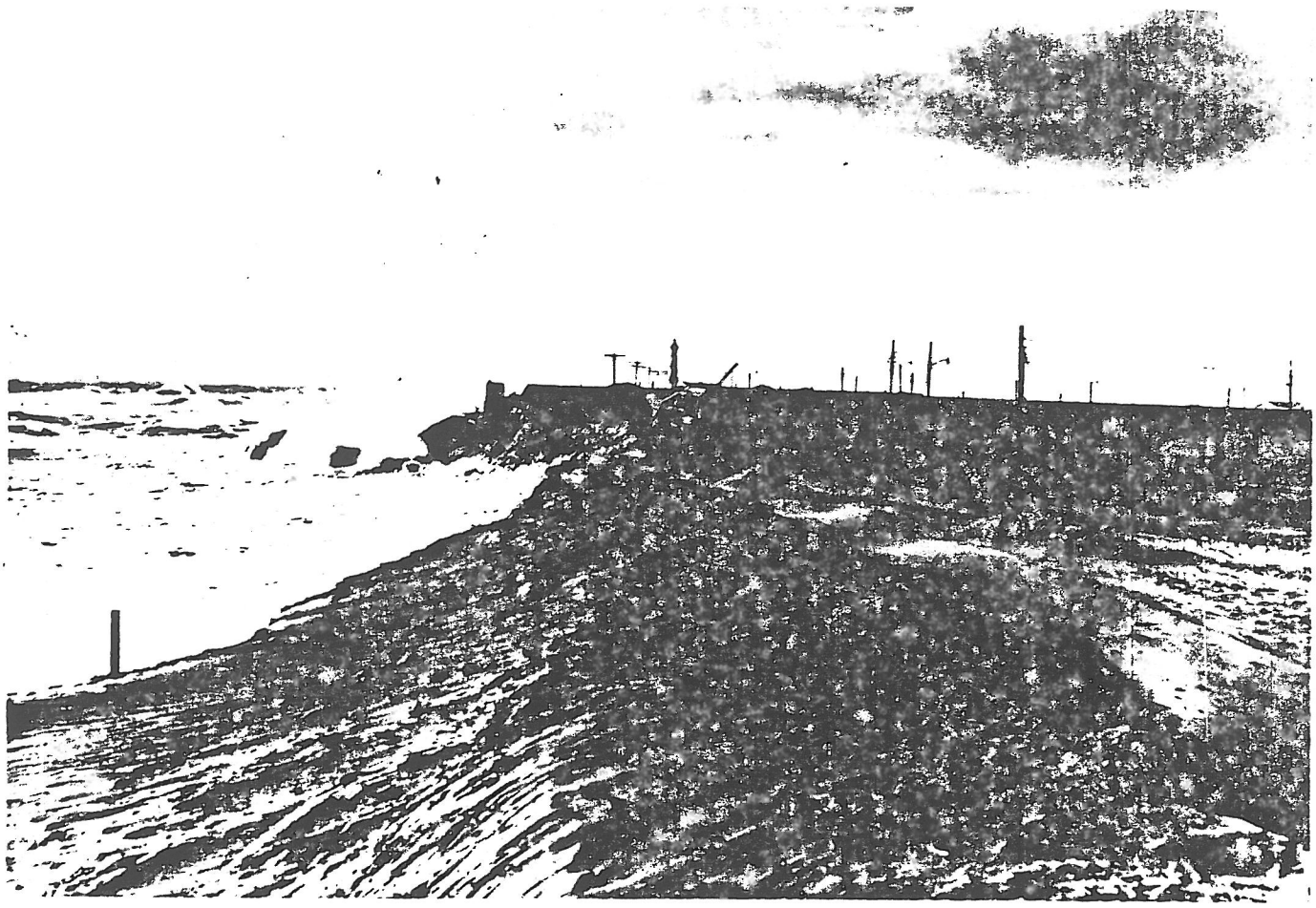

Fig. 4 In environments stressed by extreme ("Eddy") events, engineering measurements may not be successful. (NPS photo).

resources have been committed in the combination of the process manipulations.

One of the classic debates in the fields of wilderness preservation and resource conservation is whether to try to maintain environments in their pre-Columbian or some other early condition, or whether to try to maintain the natural processes (Leopold, et al. 1963). This is an interesting question, one that has seen authorities on both sides, and, some straddling the middle ground. Over the decades, the National Park Service has, in its policy, wavered back and forth.

Since Columbus landed 500 years ago, natural systems throughout the world have undergone considerable change. To try to return most natural systems to the pre-Columbian condition is realistically impossible. To try to maintain an area in the condition it was in when it came into the National Park System might be initially easier and less costly, but static or "Steady State" management requires increasing commitments of money, manpower, and energy. Ultimately—and perhaps after a rather surprisingly short span of time for the more dynamic park areas—such management will collapse entirely in the face of the inexorable march of natural processes. Until then, the natural system would have to be subjected to massive interference and reordering.

In the case of natural systems that have been directly altered by man or that are behaving unusually in response to man's influences from outside the system, there is a greater policy justification for management to eradicate the unnatural influence and to restore the system to its natural condition. In many cases, though, this is not possible, and it might be better to accept this at the

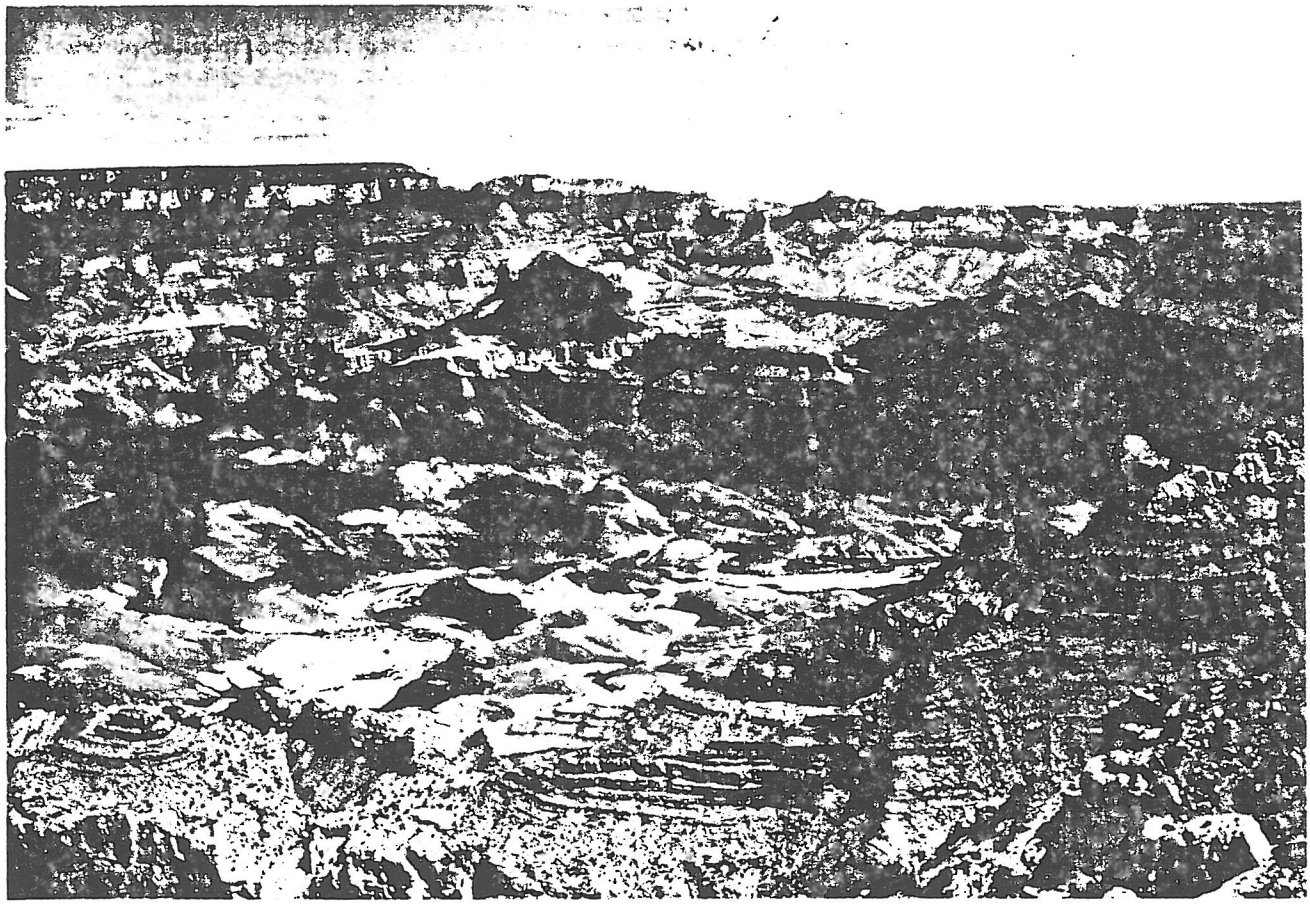

Fig. 5 Since the closure of the Glen Canyon Dam, flow of the Colorado River of the Grand Canyon is totally controlled. The demand for electricity now determines the volume, velocity, and timing of river discharge. Now the "Eddy" and "Trend States" are all but eliminated and the environmental changes have been significant. (NPS photo).

start and to save resources that might be spent on management programs that have no hope of success. If a decision is made to undertake such programs, they must be designed with an understanding of the dynamic processes involved and with an appreciation of the cost of such a commitment, which, in some cases, will require constant attention.

The Grand Canyon offers a good example where the "Trend," "Eddy," and "Steady" states of change are clearly recognizable. The "Steady States" of chemical and mechanical weathering are periodically accelerated by "Eddy State" events that cause rock falls and landslides. These processes lead toward filling in parts of the canyon. In contrast, the river etches the canyon even deeper into the substrata of the Colorado Plateau and also removes the accumulated debris during "Eddy State" floods. Since the construction of Glen Canyon Dam, the inner canyon processes have been completely altered (Dolan, et al. 1973). The "Trend State" processes have been diminished so that the curve of change is now almost flat. "Eddy State" events are now limited to small floods entering the side canyons. The "Steady State" is changing in numerous ways in response to the removal of the "Eddy State" impacts. Park managers at Grand Canyon have considered removal of new and unwanted "Steady State" phenomena—riparian vegetation and exotic wildlife, for example—and to restore the "Steady State" to something approaching its former condition (Fig. 5).

Resource managers in the Everglades can offer a good lesson to their colleagues in Grand Canyon that ultimately they must accept the new conditions imposed by the altered processes, or if these consequences are unac-

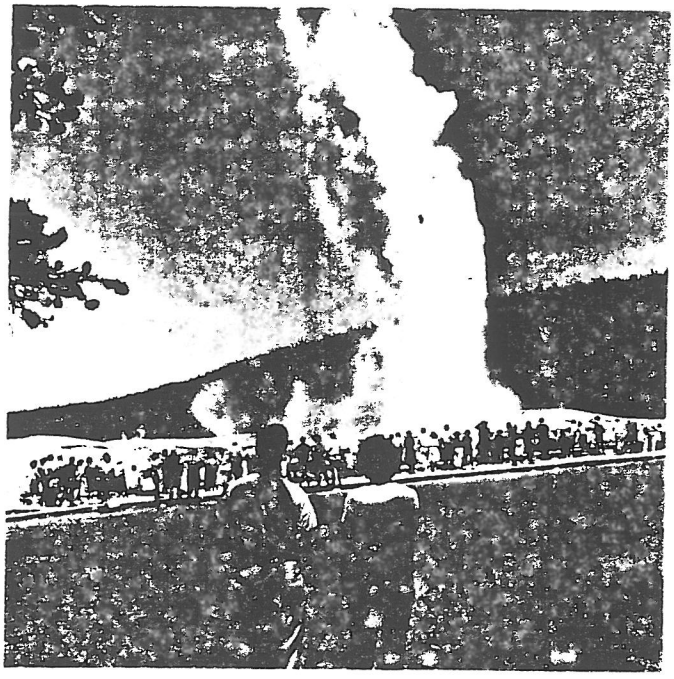

Fig. 6 The National Park Service has learned to manage visitation through understanding of visitor dynamics. In contrast, knowledge of resource dynamics is less well developed. (NPS photo).

ceptable, go outside the park boundaries to find a solution. The dynamics in both parks depend upon a substantial inflow of water from beyond the parks. In both parks the major water inflow has been altered by man and is in the control of other agencies. In the case of the Everglades, a water-supply agreement has been reached, following several years of negotiations, controversy, political contests, and legal battles. The only way the Grand Canyon can be maintained in a semblance of its past condition is to secure from the Bureau of Reclamation a delivery upon demand of "Eddy State" floods to coincide with the still natural flood stages of the tributaries. Even this will not be enough to restore the "Trend State," but over the time scale one must use in looking at the Grand Canyon, the period of Glen Canyon Dam's existence will be of questionable significance.

If one point stands out about all others in the management of natural systems, it is that management programs aimed at "Steady State" phenomena and organized about "Steady State" processes can affect only the smallest and usually least important part of the dynamic whole. resource management plan that concentrates too much e the "Steady State" will be overwhelmed by "Eddy State events or "Trend State" developments.

Designing a Dynamic Resource Management Framework

The key words in this discussion—process, change dynamics—all involve movement and time. The wa things change through time is the way they function Fluctuations in the rate of change indicate turning point in the natural process. Therefore, the measurement and monitoring of change is the keystone of resource management.

In most natural systems, the routine changes of th "Steady State" can best be measured in typical settings for example in the center of ecosystems. However "Trend States" and "Eddy States" are the more dynamic states of the processes, the ones that can provide the bes early warnings of change and management trouble Trends and episodes are best measured at those places where the transfer of energy and material are at a maximum. Most of the time, those energy flows and transfers of material are greatest across the primary interfaces or major ecotones of the system, for example: boundaries near shorelines, river channels, coral reefs, slopes, and lakes (Dolan, et al. 1973).

Numerous processes take place within every natural system and each is interesting and to some degree important. But resource managers and scientists must select and monitor the primary processes of the system. Once the primary processes have been identified, measured, and understood, once programs to monitor them have been established, there will be time to explore secondary and tertiary processes, to gather the data on the natural history, to make the museum and archive collections.

The Role of the Resource Manager

In many cases, the resource manager will be the translator of scientific material into the language of the decision-makers. He must see that the research meets the needs of the decision-maker and that the decision-maker has the scientific data necessary to make reasonable decisions. Often the resource manager will be required to interpret the data, put it into a meaningful context, and in language the layman can understand. Science founders more often on its own jargon than on the indifference

of policy-makers (Dolan, et al. 1977). Whether the decision being made is one of park management, agency policy, or act of Congress, the need for scientific data remains much the same. And the data must be adequate, pertinent, and understandable. Decisions are based on other than scientific reasons, and it is the resource manager's responsibility to see that the decision-maker fully understands the consequences and likely costs of a conclusion that runs counter to the scientific indications.

The transfer of scientific information is important not only between the researcher in the field and the decision-makers. Information should be transferred rapidly among park scientists and resource managers. Parks of similar natural process can benefit from each other's knowledge and data. Lines of communication and information transfer should not be restricted by regional, political, and other unnatural boundaries.

Parallel Park Management Strategies

This discussion outlines a departure from U.S. park resource management as it is practiced today; but the management process proposed is by no means strange to park management planning. The analogy is not quite perfect, and the terms somewhat strange, but by looking at present park visitation management in terms of the dynamic framework outlined in this paper for park resources, a parallel can be observed.

In the process of park visitation, the "Steady State" phenomena include all those daily and seasonal fluctuations in visitation rates and the ways visitors behave in the parks. They represent a wide range of impacts, but they are cyclical and routine, and the U.S. National Park Service has developed routine management methods to deal with them. When visitation is running in its "Steady State" course, the parks function very smoothly (Fig. 6).

"Eddy State" events in park visitation include the unexpected changes in visitation levels, in introductions of new modes of visitor uses, and in the nature of the park visitor. While the U.S. National Park Service is excellent in handling "Steady State" visitation, it does considerably less well coping with nude bathers, hang gliders, rock concerts, sing-ins, and other abrupt shifts in park visitation and use. As in nature, these "Eddy State" events perturb the system and the management plan.

Park visitation "Trend States" also are well known: generally increasing in volume and tending toward more highly mechanized uses on the one hand and heavier use of backcountry areas on the other. Most park visitation management plans take these trends into account, and the U.S. National Park Service does a creditable job keeping up with visitation patterns. Unfortunately, too often the Park Service's responses to visitation "Trend State" changes impact heavily on the park's natural resources.

Visitation management may not be as complex or site-specific as resource management, but it is by no means simple. The critical variables must be selected and monitored, processes must be analyzed and trends ascertained, and managerial responses and remedial steps must be devised. Visitation processes interact with and have secondary effects upon one another. Park managers have learned to cope and to cope very well with this complex interplay of dynamics and the effects caused by 200 million visitors using the U.S. parks, monuments, seashores, and others areas in the system.

Conclusion

To conclude, these basic generalizations are submitted for consideration:

- Management actions designed to control and stabilize the natural landscape usually result in unexpected side effects that in turn require additional management action.
- Management actions to control the landscape are mostly site-specific. Therefore, procedures that were successful in one location may not be successful when applied elsewhere.
- The policy of managing the national parks should be to preserve and wherever possible to permit the evolution of the dominance of natural forces and the resulting landscapes and ecological scenes. This view should not be construed as a policy of neglect, but understood as a position of living with nature as opposed to one of man attempting to control nature. Any concession to this philosophy should be viewed as major departure in principle, merited only when irreplaceable features of national significance are in question.
- Interpretive programs administered by informed personnel are essential to successful application of this type of resource management policy. Application of the philosophy of adjusting to and living with the forces of nature will require new efforts to inform the public of the constructive nature of an everchanging landscape where the "Eddy State" and "Trend State" play significant roles in maintaining the environmental health of the National Parks.

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